



# **Creating a Shared Virtual Environment using a Head- Mounted Display and a Smartphone**

Bachelor Thesis  
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# Strengths of VR

- Immersive
- Intuitive 3d manipulation
- Intuitive visualization



# Challenges of VR

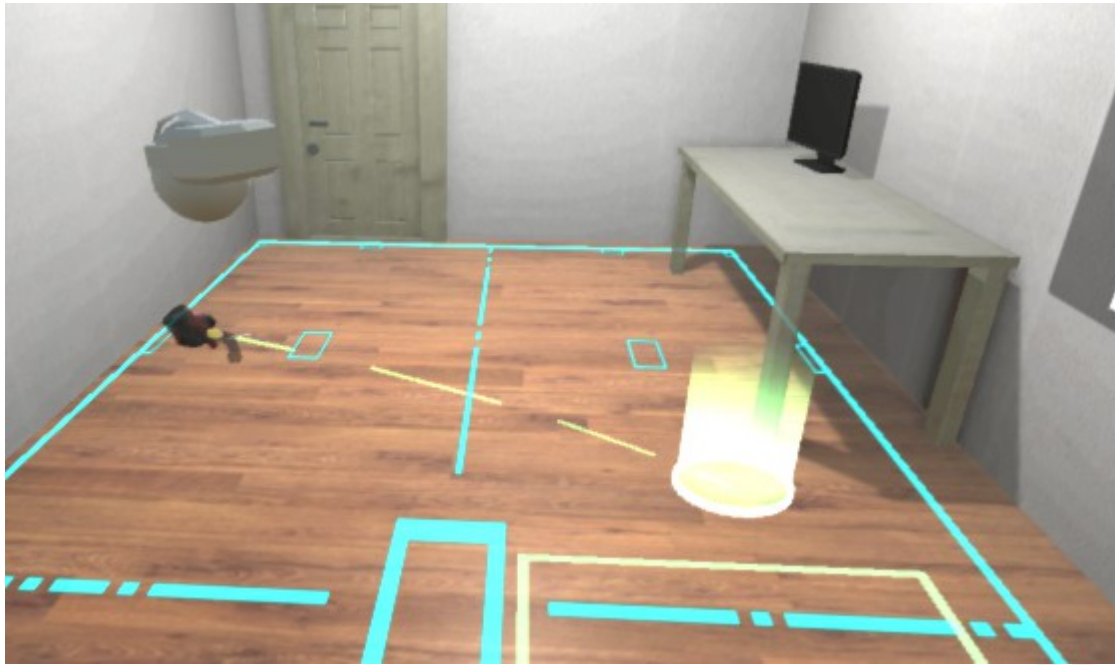
- Isolation of the user
  - Multi-user is difficult because
    - Hardware requirements
    - Space requirements
    - Convenience

# Concept

- Make use of ubiquitous screens
  - use smartphones to interact with the virtual environment

# Implementation

- HTC Vive and Unity
- Synchronized scenes via Internet



# Implementation



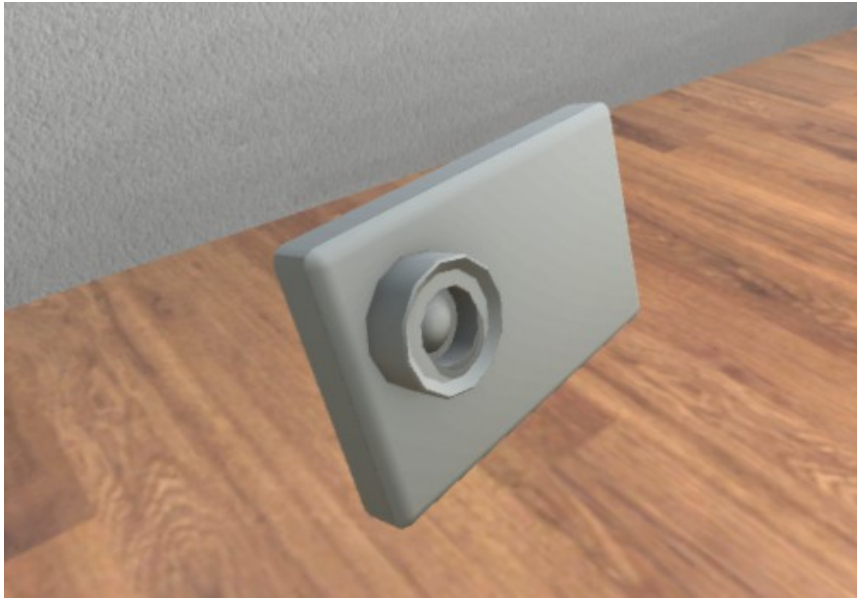
# Avatars

- VR user from Smartphone user's Perspective



# Avatars

- Smartphone user from VR user's Perspective





# Study Concept

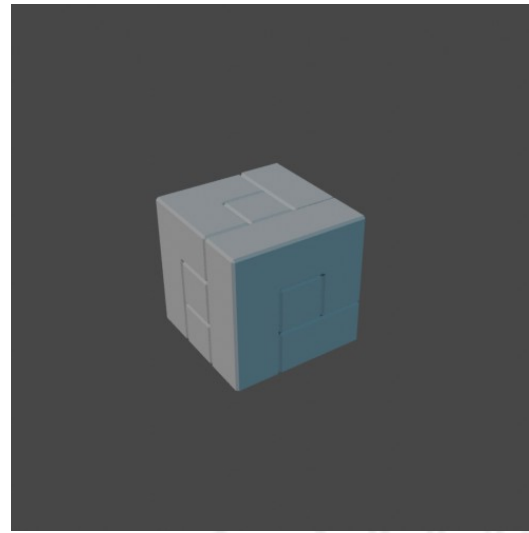
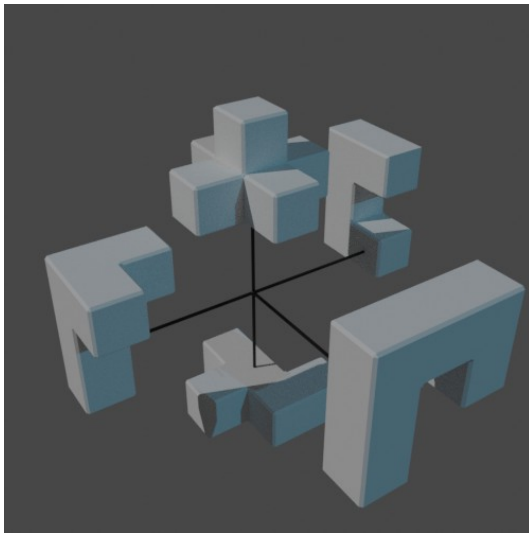
- Inbetween user Study
- Pairs of participants solve a Task cooperatively
- Measure differences in the User Experience

# Hypothesis

- Reduced cognitive load for VR user
- Reduced cognitive load for smart-phone user.
- Improved performance in solving the task

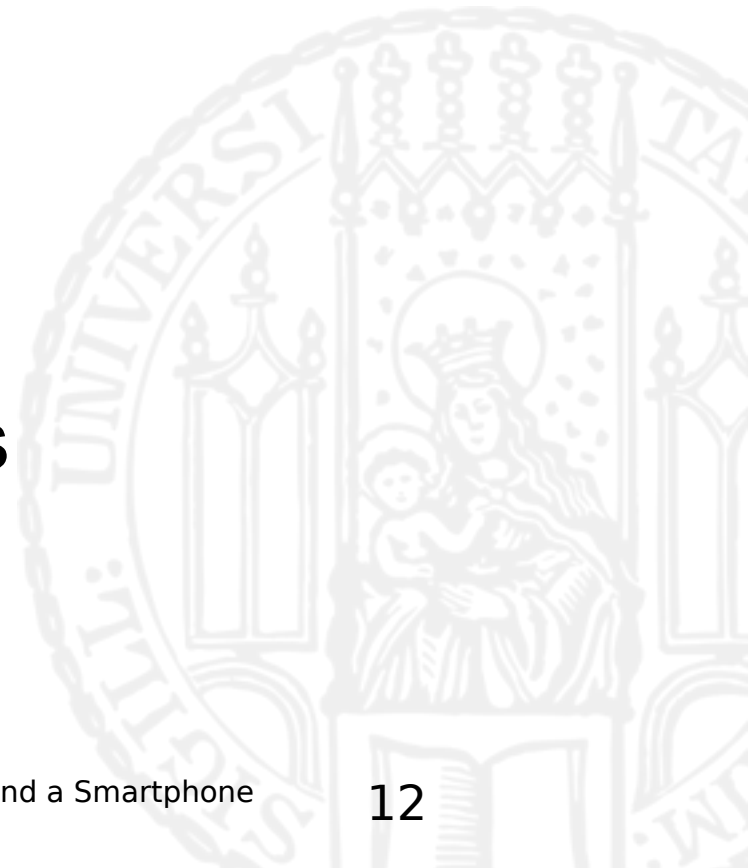
# Task

- Cube Puzzle



# Collaboration

- VR user
  - Manipulates puzzle
- Smartphone user
  - Observes VR user
  - Access to instructions



# Smartphone User



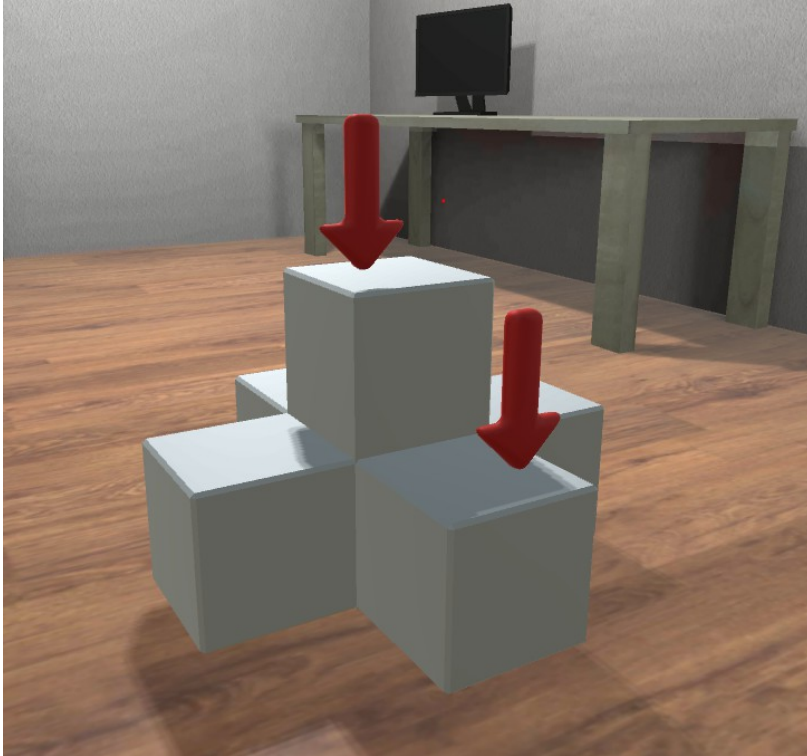
# Interactive Instructions



# Interactive Instructions



# Pointer system



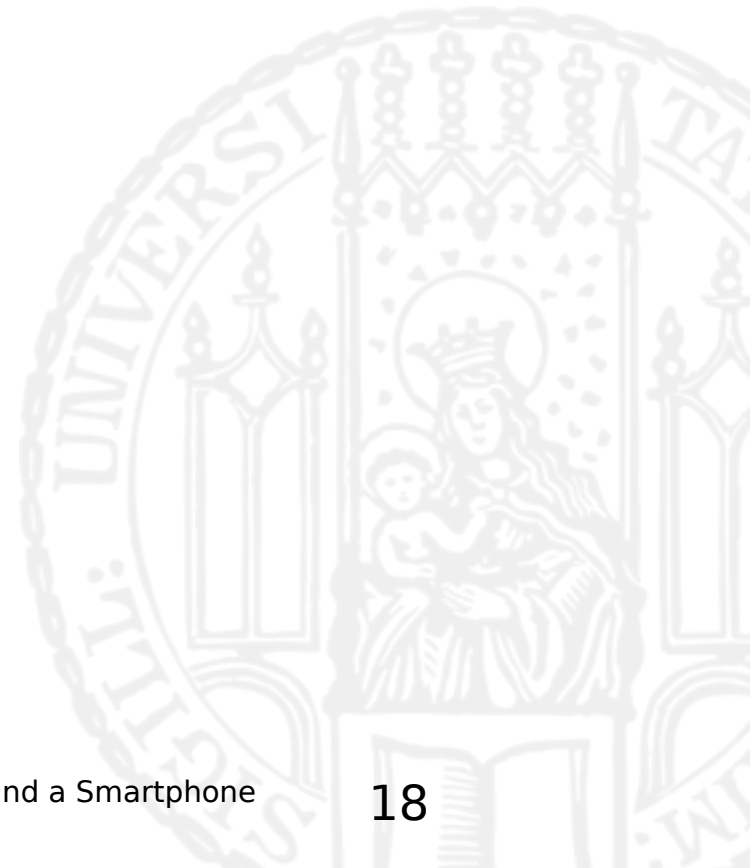


# Dependent Variables

- Performance:
  - Time to complete, moves
- Cognitive load:
  - NASA TLX
- Verbal communication:
  - Amount of instructions in categories

# Independent Variables

- Group A
  - Full version
- Group B
  - Limited version



# Limited version

- Smartphone user only has access to the solution.



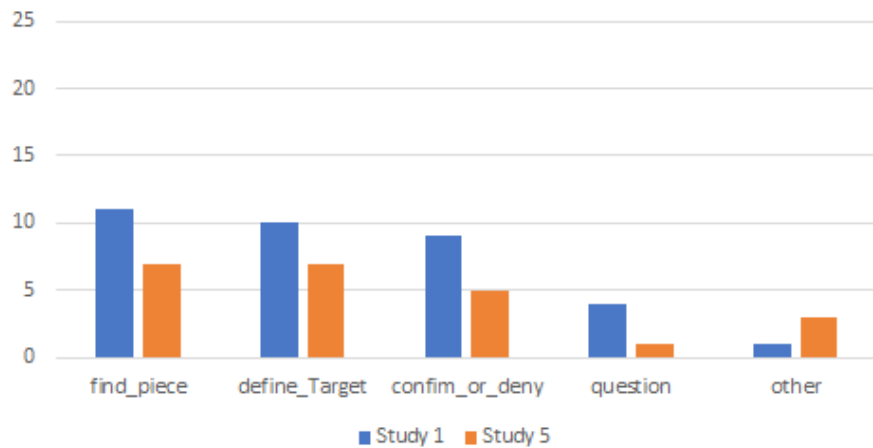
# Results

- 10 participants, 5 pairs
- 6 female 4 male

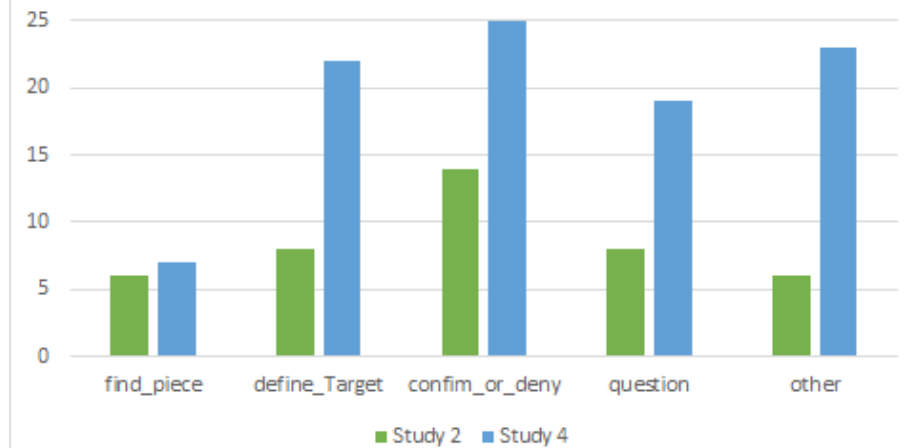


# Verbal communication

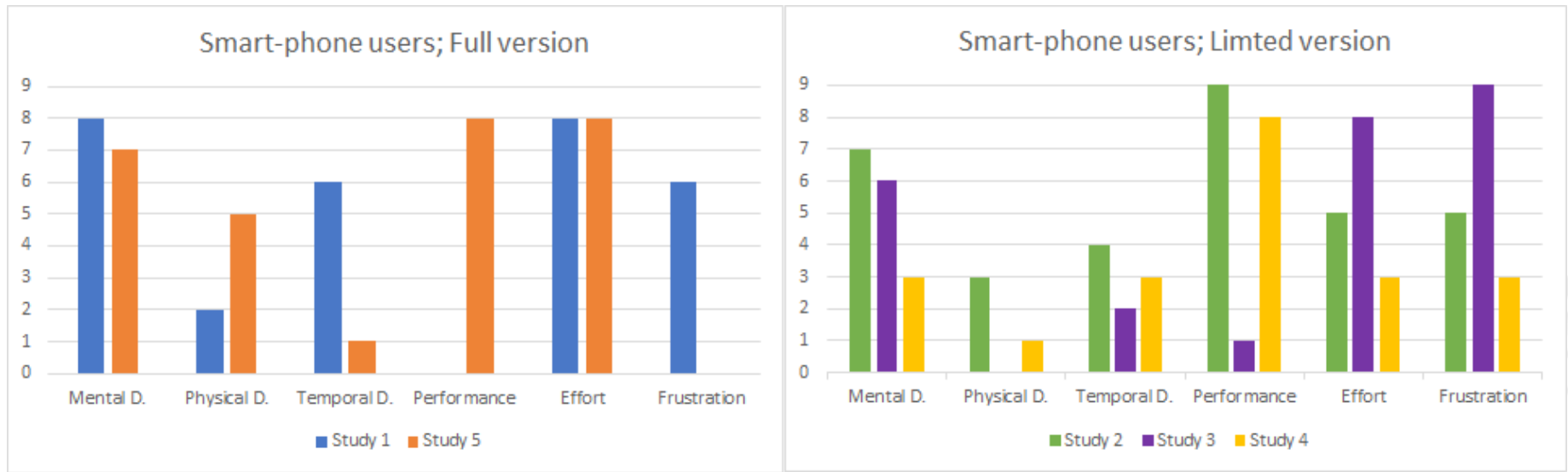
Verbal communication; Full version



Verbal communication; Limited version



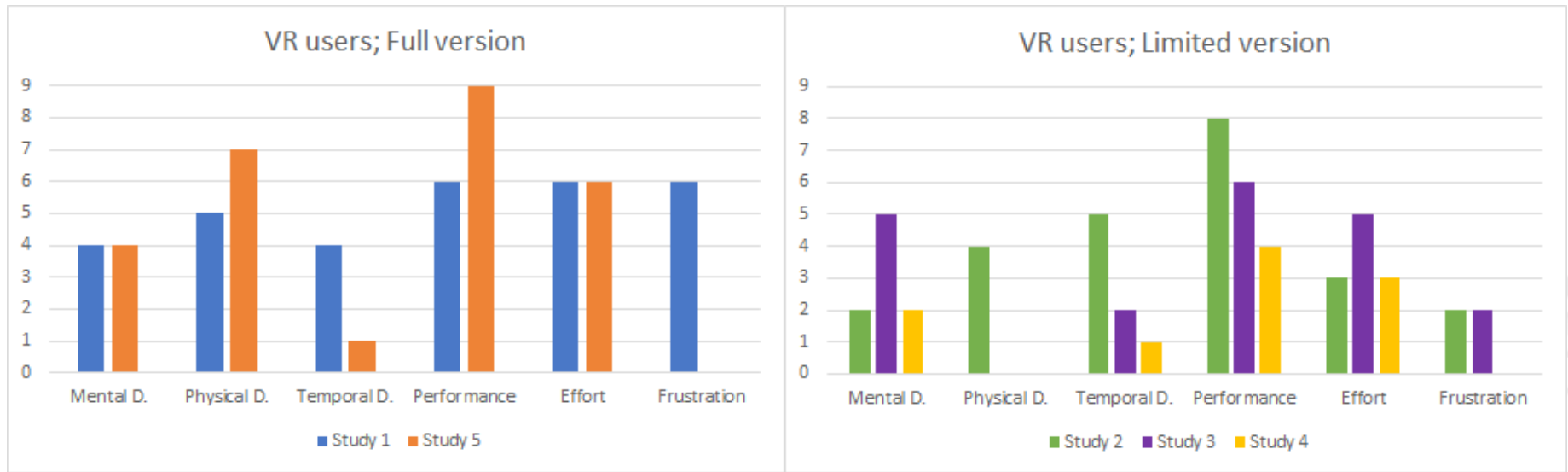
# Cognitive Load



Independent two-sample T-test:

$$t = 0.131$$

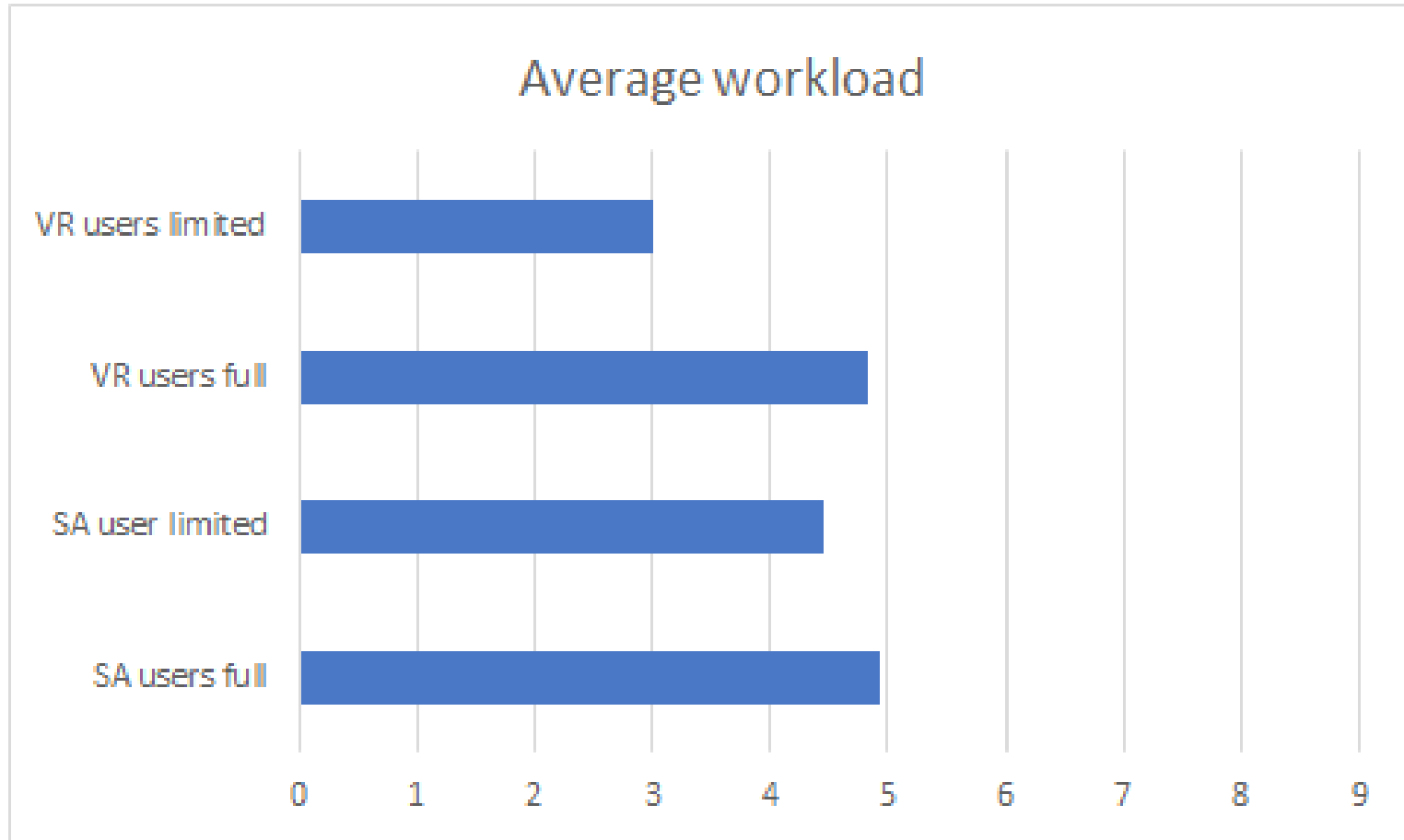
# Cognitive Load for VR users



Independent two-sample T-test:

$$t = 0.863$$

# Workload





# Performance Averages

- Full Version:

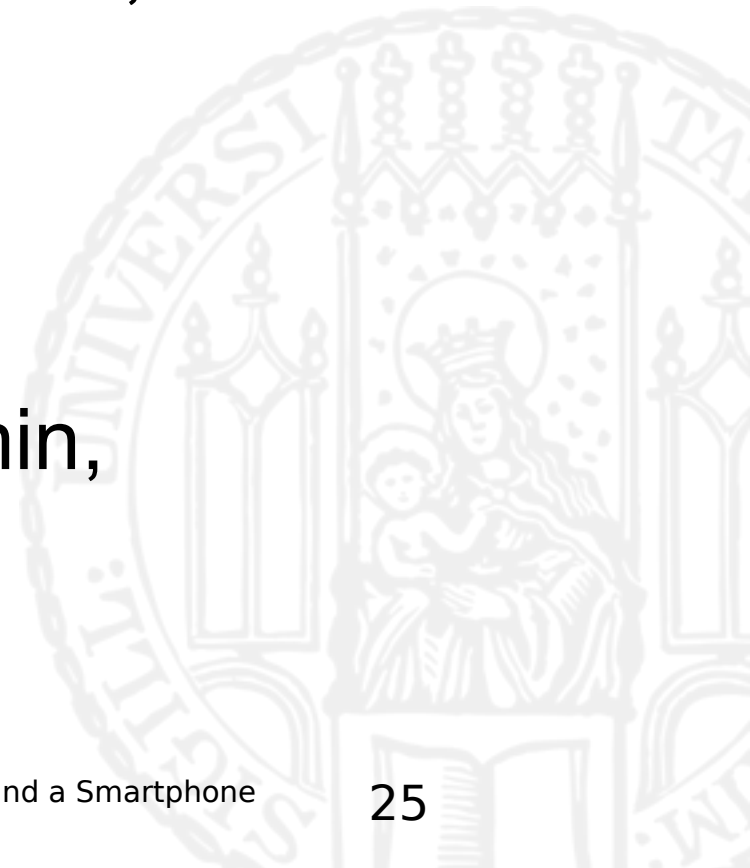
avg. time: 10:11 min,

avg. moves: 35

- Limited Version:

avg. Time: 8:58 min,

avg. moves: 21



# Conclusion

- No reduction in cognitive load
- No Improvement in Performance
- Significant reduction in Verbal Communication

# Conclusion

- Possible causes:
  - Increased Complexity
  - Learning curve
  - High variation in skill

